Spring 5-11-2020

Chemistry in Art: The Science of Dye

Madeleine Gray Burland
madeleb@bgsu.edu

Chemistry in Art: The Science of Dye

Madeleine Burland

Honors Project

Submitted to the Honors College
at Bowling Green State University in
partial fulfillment of the requirements for graduation with

UNIVERSITY HONORS
May 8, 2020

Dr. Barbara Bergstrom, Advisor
College of Arts and Sciences

Dr. Ekaterina Meijiritski, Advisor
Chemistry Department

Project Summary

When I was first trying to develop this project, I wanted to find a way to teach both chemistry and art, and to combine the two in a lesson for the art classroom. I was considering a project that focused on the process of making paper for a long time, looking at the art of origami, but I ended up changing my mind after a batik class I took over the summer. Batik is a type of fabric art that uses wax as a resist so that only areas without wax on the fabric end up being dyed. And when I took this class, we had one day that focused on shibori, a Japanese resist technique involving sewing into the fabric, then tightening the stitches to create areas of resist on the fabric. The most interesting thing about this project was that we used natural materials to make dye instead of using synthetic dyes. This is where I found the inspiration for my project, because the science behind making dye, especially from natural materials is a fascinating subject, and I thought a fabric arts lesson with a focus on experimentation and testing of different materials to create various dyes could become an engaging multidisciplinary art lesson.

From there, I developed a series of research questions:

1. In what ways can I incorporate topics of chemistry into the art classroom in order to create an interdisciplinary learning environment and foster student growth?
2. How can I develop a lesson plan that incorporates elements of the scientific method on the topic of fiber arts and natural dyes (dyes of colorants derived from plants, invertebrates, or minerals)?
3. Can the art classroom be used as a tool to help students develop practical skills that will benefit them in other areas of study?

There were two main components that made up this project. The first being lesson plans written in EdTPA format, that planned out the lesson over a series of days. In writing these out, I

wanted to develop a cohesive unit of lessons that incorporated fabric arts and natural dyes, but more importantly, provided an opportunity for students to take ownership of their own work by giving them the freedom of choice through every step of the project, and allow them to experiment and explore the subject of natural dyes in order to experience those processes for themselves, and really find an area of this topic that interests them.

The second component to this project focused on collection of data and experimentation of my own in the form of test samples of a few different natural dye materials. When choosing materials, I wanted to take into consideration the fact that a school may not have a very large budget to work with for art lessons, so I tried to limit the materials to inexpensive things that can be found at any typical grocery store. For dyes, I tested common fruits and vegetables; avocados, blueberries, celery, carrots, coffee, nothing too far out of the ordinary. For fabric, I used two different types of muslin, which are 100% cotton. All-natural fabric was necessary for this project, because the natural chemicals in plants won't bond as well with synthetic materials like polyester.

In the process of trying to get a wide range of colors of dye, I tested a lot of materials, and some of them worked, while some had no result at all. I set up the experimentation portion of this project to test a number of variables that might affect the color of the dye. First, I used two different types of muslin, to see if a different fabric would result in brighter or different colors. I also tested the impact of a mordant (a substance, typically an inorganic oxide, that combines with a dye or stain and thereby fixes it in a material) on the dye, to see if having it was important to helping the dyes hold. From the test samples, I found that neither the difference in fabrics nor the use of mordant had any effect, however some dyes aren't wash-fast or even light-fast, meaning

they'll fade with washing or just exposure to light, and so the mordant might prove to have an effect later on.

Of the ones I tested, I found that coffee, avocado pits, blueberries, pomegranate seeds, black beans, paprika, and basil, worked fairly well, however I saw no results from celery, artichokes, carrots, or lemons. In the cases of the four that didn't work, the initial color of the dye bath was lighter than those that did work, suggesting that there aren't as many colorants in these vegetables that would be able to bond to the fabric. It's also possible that I didn't prepare the dye or fabric in the best way to produce a bright color. Much of the dye I was able to make came just from boiling the natural materials, but the literature of producing dye comes mostly from DIY sites, and so there are conflicting instructions on what will work for different plants.

The avocado pits I found to be the most interesting and surprising, primarily because the color dye they produce is a light red, which was unexpected based on the color of avocados. As shown in the pictures of the process, I made the dye first by heating a pot of water to boiling. I then added three pits to the water, lowering the temperature to a simmer. The longer the pits were in the water, the darker the water became as it pulled the colorants out of the pits. The pits themselves also changed, the hard, outer layers beginning to open, which may have helped increase the concentration of dye. After about 40 minutes of simmering, I let the dye cool, then added the fabric. I found out later that a good step to include is to strain the dye and remove the natural materials so they don't get on the fabric, but it didn't seem to affect the fabric much. The dye worked almost right away, but with the avocados and most of the other dyes, the longer the fabric remained in the dye, the stronger the color became. This was especially true for the blueberries, which became very dark after 18 hours in the dye. Blueberries also worked well as a

dye, and not only changed dramatically with time, but I was able to get a completely different shade of purple from them by using old berries.

Along with testing plain squares of fabric, I also tested a couple shibori techniques, stitching lines and shapes in the fabric, and using cardboard shapes and rubber bands as a resist to create samples of a few basic techniques. I found that for the stitching, a simpler pattern worked better, and the areas of resist were stronger if the fabric wasn't in the dye for very long. However, the cardboard was able to stay in longer without the dye filling in the areas of resist. I included pictures of the silk I used in my summer batik class. In general silk seemed to hold the patterns better than the cotton, but because silk is much more expensive, it'd be unlikely that it could be used in a classroom setting, and the cotton works well enough.

By performing all these tests and experiments, I feel that now I have a better understanding of the process of making and using these dyes, as well as some of the problems that might occur and how to solve them. From here, I think it would be feasible to incorporate this project into the classroom, and use it as a way to teach not just shibori and fabric arts, but chemistry, experimentation, and the scientific method. While I was doing the tests, I found myself changing procedures, and trying different things to try and get a color from the fruits and vegetables, and in some cases I was successful and in others I wasn't. In teaching this lesson, my hope is that students will be able to go through the same process I did, by finding and testing vegetables and plants other than the ones I used, using my samples as a guide for what may work instead of a rulebook of what materials will and won't work, and I think making experimentation instead of success the goal for my students will be my biggest challenge in teaching the lesson, because it is disappointing when the dyes don't work, or don't turn out how they were supposed to.

Although I was unable to get a full rainbow of colors out of the testing process like I'd hoped, I feel like the colors I did get, as well as the ones I didn't get are a good foundation for when I teach the lesson in the future, and for my students to consider when planning their projects. I have by no means learned everything there is to learn about the process of dyeing and natural dyes, but the fact that there's so much to the subject will make it better to teach and give my students more creative freedom and room for experimentation, which was the primary goal I had for this lesson and this project.

From having the chance to test and experiment with a number of different plants and vegetables to make natural dye, I have found that there are many variables to consider and the process of making dye is not as straight forward as I first thought. By going through some of the trial and error myself, I hope to be able to better support my future students in the execution of this lesson and help them to work through and overcome any problems they encounter. Overall, the goal of this project was to develop a lesson plan that can be applied to a high school art room setting and be used to incorporate multidisciplinary learning into the classroom by introducing students to topics in chemistry through art education. This project has given me a deeper insight into multidisciplinary teaching strategies, as well as pushed my knowledge of how to teach chemistry as well as art, while creating a foundation for a future curriculum specifically designed to combine art and chemistry in the classroom.

Lesson Plans

Unit/Lesson Sequence title: Chemistry in Art: The Science of Dye
Grade level: 9-12
Number of Students: 10-12

Enduring Understanding: By applying principles of experimentation to the art making process, students will experience the practical application of the scientific method through the lens of the chemistry of dye and the art of shibori.

Language Function

Students will question the nature of dyes and experiment with different dyeing materials to achieve the desired effect in a piece of artwork.

Lesson Rationale and Summary

Rationale: This lesson will introduce multidisciplinary learning into the classroom by focusing on the ways art and chemistry interact under the umbrella of natural dye. By adding a component of experimentation and independent study to the traditional Japanese art of shibori, students will simultaneously work through the scientific method and creative problem-solving process as they work to find and test natural materials for dye. Students will develop habits of persistence as well as critical thinking skills as they experiment with different materials and processes to get the colors and patterns needed for their projects. **Summary:** Students will use the art of shibori and natural dye materials to dye an article of clothing of their choice. Students will incorporate the scientific method and practices of scientific investigation and experimentation as they work with and test various natural materials to produce the desired dye colors.

Lesson Objectives / Learning Targets

The students will…	Lesson Objectives / Learning Targets	ODE Code	Visual Arts Standard	Assessment/Evaluation of evidence
1	Students will understand the basic principles of dyes and dyeing.	HSI.2PR	Apply and defend the selection of materials and techniques.	Explanation of why specific plants were chosen to produce the desired colors.
2	Students will compare and contrast various sources on dyeing to find procedures and strategies for dyeing with natural materials.	HSI.1CR	Develop a practice of engaging with sources for idea generation.	Submitted bibliography of sources used.

3	Students will analyze the results of dye tests and make changes in process based on results.	HSI.2RE	Apply self-assessment practices to revise and improve artworks and document learning.	Written reflections on each dye test explaining the process, what went well, what went wrong, and possible changes.
4	Students will test and experiment with natural dyes and the dyeing process.	Chemistry Obj. 1	Design and conduct scientific investigations using a variety of methods and tools to collect empirical evidence, observing appropriate safety techniques.	Submission of test samples of different dyes and shibori techniques.
5	Students will learn to classify various natural dye materials according to their different characteristics.	Chemistry Obj. 2	Formulate and revise explanations and models using logic and evidence (critical thinking).	Collaborative dye chart, showing students' test results in an organizational structure of their choosing.
6	Students will understand the connections between science and art.	Chemistry Obj. 3	Science depends on curiosity, imagination, creativity and persistence.	Class discussion of how chemistry and art are intrinsically linked.

Vocabulary

Content vocabulary:

- Shibori

General vocabulary:

- Muslin
- Natural Dye
- Mordant
- Pigment

Instructional terms:

- Running stitch

Differentiated Instructional Strategies

- Visual: Pictures will be included in the powerpoint presentation. Samples of dyed fabric will be available for students to reference. Demos on dyeing will be done in class for students to see the procedure.
- Verbal: Students will be given opportunities to explain their ideas to the teacher or their peers at various stages of the project.
- Kinesthetic: Fabric samples of different dyes and shibori techniques will be passed around for students to examine.
- **Project extensions for gifted exceptionalities**: Students will be challenged to experiment with other aspects of dyeing and fabric arts that interest them, such as combining materials or dyeing multiple times, using the dyed fabric as part of a sewing project (making clothes, pillows, etc.).

Language Demand

Syntax: Vocabulary will be defined in the presentation and I will continue to use it when giving a demonstration so students can see how to apply it.
Discourse: Students will use vocabulary during class discussions and conversations with the teacher.

Lesson ___1__ of ___6__
Lesson title: A History of Dyeing

Planned Assessments

Pre-Assessment: Question and answer session on what students know about dye and the process of dyeing, if they've dyed things before, what they understand about the dyeing industry and synthetic vs. natural dyes, the chemistry of dye, and whether they think dyeing fabric is a type of art.

Formative Assessment:

1. Sorting game covering which materials students think produce which color dye. (Obj. 2)
2. Discussion of what materials students think they might want to use for dyeing. (2PR)

Lesson Resources

Equipment: Computer, projector, screen

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp

Supplies: Large pot, dye material (blueberries), small pieces of fabric (100% cotton), prepared shibori to dye, scrap fabric, needles, thread, scissors

Instructional support materials: Powerpoint presentation, teacher samples

Lesson Procedures

	Teacher actions	Student actions
Assessment of Prior Learning or Pre-Assessment	Question and answer session on what students know about dye and the process of dyeing, if they've dyed things before, what they understand about the dyeing industry and synthetic vs. natural dyes, and the chemistry of dye.	
Lesson Opening/ Introduction	I will begin the class with a powerpoint presentation, introducing the students to dyes and dyeing, discussing synthetic dyes, where and how they're used, and the impact they can have on the environment. I will also discuss natural dyes, and some of the similarities and differences between the two types of dye. I will introduce how fabric dyeing has been an important part of human culture for a long time, talking about how it was used in the past and how it's used today, looking at different dyeing techniques and focusing on shibori and relating it to tie-dye, which many students have likely done or seen before.	Students will reflect on how dyed fabric and materials plays a role in their own lives, and the kinds of dye they've used before if any. Students will consider how tie-dye is similar to and different from shibori.
Allotted Time	20 minutes	
Formative Assessment	Sorting game covering which materials students think produce which color dye. (Obj. 2)	
Body of Lesson	After students sort the dye materials, I will pass around a number of test samples of different dyes and shibori techniques for students to examine, discussing how the colors produced with natural materials are different from those you get with synthetic dyes. I will also take some time to answer any questions students have about dyes and/or shibori. I will then introduce students to the project, dyeing an item of clothing of their choice, and ask them to begin thinking about what they might want to do for their project, what colors, patterns, and techniques they might want to try to create something they would actually wear. Next, I will perform a demo on dyeing using blueberries as dye, showing students the general process of making the dye, and explaining some of	Students will reflect on the samples being passed around, looking at what they do and don't like to begin figuring out what they might want to try. Students will observe the process and consider how they might need to change things based on the

	the intricacies of the process, some tips that might help them, and the qualities of the different materials that could affect how the dye comes out. I will also do a quick demo on sewing/stitching for those who don't know how, while the other students can get to work on shibori samples.	materials they might want to try.
Extra activity:	Students will begin trying various shibori techniques, finishing 3-4 small samples by the next class.	
Allotted Time	30 min.	
Lesson Closure	I will go around the class and ask students what materials they're thinking about using and/or what colors they might want to try to get from the dyes. For the next class, I will ask students to bring in 3-4 test samples of shibori techniques, and a rough sketch of what they want their final product to look like.	Students will consider the material introduced during class and make a decision on what colors and materials they want for the project.
Allotted Time	10 min.	
Formative Assessment	Discussion of what materials students think they might want to use for dyeing. (2PR)	
Summative Assessment	See Lesson 6	

Lesson ___2__ of ___6__
Lesson title: Chemistry in Art

Planned Assessments

Formative Assessment:
1. Class discussion of how chemistry and art are connected (Obj. 3)
2. One-on-one discussions about students' plan for final product, clothing being dyed, dye design, dye materials being used, etc. (2PR)

Lesson Resources

Equipment: Computer, projector, screen, large pots containing pre-made dye, pot of mordant.

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp.

Supplies: Towels, scraps of fabric, needles, thread, scissors, poles, string.

Instructional support materials: Powerpoint presentation, teacher samples.

Lesson Procedures

	Teacher actions	Student actions
Lesson Opening/ Introduction	I will begin by continuing the powerpoint from the previous class, reviewing some of the main points discussed during the previous class (history of dye, etc.) I will then introduce the chemistry aspect of this lesson, discussing how chemistry can be found in many kinds of art, asking students where they can see science and art interacting, especially when it comes to dye. I will also go over the chemical structures found in plants as a way to classify natural dyes.	Students will recall and reflect on what was introduced in the last class, and discuss the connections between art and chemistry.
Allotted Time	10 min.	
Formative Assessment	Class discussion of how chemistry and art are connected (Obj. 3)	
Body of Lesson	I will introduce students to the more scientific aspect of the project, explaining the scientific method and how I want them to use it to get at least one unique effect from the natural materials, by testing various materials, procedures, and other things they can think of based on information they can find online about dyeing to create their own technique. For the remaining work time, students will be doing one of three things, either discussing their plans for their final product one-on-one with me, finishing their shibori samples (if they haven't already) and testing the premade dyes, researching different dye materials and techniques to see what they might be interested in experimenting with. For students testing shibori, they will have the option of taking them out of the dye before class is over, or leaving the fabric in the dye overnight to get a more intense color.	Students will reflect on how the scientific method mirrors the creative process in many ways. Students will show focus and persistence, staying on task with whatever they choose to do for the work time.
Extra activity:	Students will try pole-wrapping (a shibori technique).	
Allotted Time	40 min.	
Formative Assessment	One-on-one discussion with each student about the direction they plan to go for the project. (2PR)	
Lesson Closure	I will reiterate how art and chemistry are interconnected, and how the scientific method is similar to the creative process in many ways. For the	Students will practice good note-taking skills as they begin collecting

	last few minutes of class, I will ask students to write in their sketchbooks which shibori techniques and dyes they tested that day as well as any helpful sources they found, to begin collecting data and information about the process. (1CR)	information that will inform their projects later on.
Allotted Time	10 min.	
Summative Assessment	See Lesson 6	

Lesson ___3__ of ___6__
Lesson title: The Scientific Method

Planned Assessments

Formative Assessment:
1. Students will reflect on their initial test results in a written reflection in their sketchbooks. (2RE)
2. Progress made on dye chart. (Obj. 2)

Lesson Resources

Equipment: Computer, projector, screen

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp

Supplies: Large poster-board, push pins, paper for labels (for dye samples), needles, thread, scissors

Instructional support materials: Powerpoint presentation, teacher samples, note organization samples (online)

Lesson Procedures

	Teacher actions	**Student actions**
Lesson Opening/ Introduction	I will begin the class by recapping what happened last time, reminding students about the connection between chemistry and art, and the dyeing they were able to do last time. I will have students get out all the samples they made and put them on the table so everyone can walk around and see each other's results. After everyone has had a chance to look at everything, the students will sit down and record the results from their initial tests in their sketchbooks.	Students will consider how their and their classmates dye samples turned out, looking to see if there are any colors or techniques they might want to try for their final.
Allotted Time	15 min.	

Formative Assessment	Students will reflect on their initial test results in a written reflection in their sketchbooks. (2RE)	
Body of Lesson	As a class, students will begin working on a "dye chart" showing the results of all the tests they've done so far, organized in a classification system of their choosing on a large poster-board. I will tie this back to scientific principles, data collection, and the periodic table. While the students are doing this, I will encourage discussion by asking questions about their results, and why they think things turned out the way they did, if one sample turned out better and why, how are the students organizing things and why, etc. I will also ask students about other materials they want to try as a class or any techniques they want to try that they thought of or haven't done yet.	Students will work collaboratively to organize the results of their tests. Students will think critically about the best way to arrange the samples in a way that makes sense for what's there already, while also making it possible to incorporate new samples as they're made and added.
Extra activity:	Students will begin stitching the shibori design for their final project.	
Allotted Time	40 min.	
Lesson Closure	Remind students that the next class period will be a chance for them to test more dyes and to think about trying something beyond what I've talked about with shibori to see if they can do something new with it or with dye. For the next class, I will ask students to prepare a table in their sketchbooks to make it easier for them to record notes about their tests, however they want to do it, putting a couple samples online for them to look at.	Students will decide for the most part what they want to do for their final product.
Allotted Time	5 min.	
Formative Assessment	Progress made on dye chart. (Obj. 2)	
Summative Assessment	See Lesson 6	

Lesson ___4__ of ___6__
Lesson title: Test Day

Planned Assessments

Formative Assessment:
1. Table in sketchbook for taking notes on dye tests (2RE, Obj.1).
2. One-on-one discussions. (2PR, 1CR)

Lesson Resources

Equipment: Computer, projector, screen

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp.

Supplies: Large pots, dye materials (specified by students), small pieces of fabric (100% cotton), scrap fabric, needles, thread, scissors, poles, yarn/twine, towels.

Instructional support materials: Powerpoint presentation, teacher samples

Lesson Procedures

	Teacher actions	**Student actions**
Lesson Opening/ Introduction	I will begin the lesson by reminding students what we did during the last class (dye chart, recording information) and tell them that this class will mostly be a work day, but I will be talking to them individually about their final design for their project.	Students will reflect on what they did during the last class.
Allotted Time	5 min.	
Formative Assessment	Table in sketchbook for taking notes on dye tests (2RE, Obj. 1).	
Body of Lesson	Students will spend the majority of the class period doing dye tests. While they are working, I will go around and talk to them one-on-one about their final project, how their samples are turning out, and what new techniques, if any, they're trying, and if they've found any sources of inspiration for their project.	Students will demonstrate persistence and creativity in the tests they do in preparation for their final project.
Extra activity:	Work on shibori stitching for final project.	
Formative Assessment	One-on-one discussions. (2PR, 1CR)	
Allotted Time	50 min.	
Lesson Closure	Tell students that we'll be dyeing the final project next class so they'll need to be done stitching before class starts.	
Allotted Time	5 min.	
Summative Assessment	See Lesson 6	

Lesson ___5__ of ___6__
Lesson title: Make it Work
Planned Assessments

Formative Assessment:
1. Sketchbook entries detailing results of tests from the previous class period. (2RE)

Lesson Resources

Equipment: Computer, projector, screen

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp

Supplies: Large pots, dye material (blueberries), scrap fabric, needles, thread, scissors,

Instructional support materials: Powerpoint presentation, teacher samples, dye chart

Lesson Procedures

	Teacher actions	**Student actions**
Lesson Opening/ Introduction	To start class I will let students know that the entire period will be a work day for them, and remind them to look at their samples when dyeing their final projects. I will also ask students to record the results of their most recent test samples in their sketchbooks.	Students will consider the best approach to getting the result they want in their final project.
Allotted Time	5 min.	
Formative Assessment	Sketchbook entries detailing results of tests from the previous class period. (2RE)	
Body of Lesson	While students work on their projects I will be available to help with any last-minute projects and answer any last-minute questions.	Students will work on their final projects.
Extra activity:	Incorporate finished dye samples into the dye chart.	
Allotted Time	45 min.	
Lesson Closure	Remind students that our next class will be our critique.	
Allotted Time	5 min.	
Summative Assessment	See Lesson 6	

Lesson ___6__ of ___6__
Lesson title: Fashion Week/Final Critique

Planned Assessments

Formative Assessment:

1. Submission of completed dye chart. (Obj. 2)

Summative Assessment: Students will wear final project to class, finish dye chart, submit written notes on dye samples, physical samples labeled, and bibliography of sources used in research.

Lesson Resources

Equipment: Computer, projector, screen

Health & Safety: Stoves/heat sources, and boiling water can cause burns, natural materials may cause allergic reactions, needles are sharp

Supplies: Camera

Instructional support materials: Powerpoint presentation, teacher samples, dye chart

Lesson Procedures

	Teacher actions	**Student actions**
Lesson Opening/ Introduction	Students will complete the dye chart with their test samples at the beginning of class before the critique.	Students will follow the organizational system they developed together to complete the dye chart.
Allotted Time	10 min.	
Formative Assessment	Submission of completed dye chart. (Obj. 2)	
Body of Lesson	We will have a class critique on students' final projects, each student will describe their clothing item, what material(s) they used, what technique/method they used to dye it, and what they thought went well and what they thought they could do better. Students will comment on what techniques appeared successful, and give feedback on the results of their classmates.	Reflect on the dyeing process, their own and others', and how their final project turned out, what went well, what went wrong.
Extra activity:	Photoshoot of students wearing their dyed clothing.	
Allotted Time	30 min.	
Lesson Closure	I will ask the class as a whole to discuss how they see science and art interacting now that they have	Students will reflect on the interactions between

	done an art project with a more scientific foundation. I will ask them if they see any similarities between the scientific method and the creative process, and if they think this knowledge/experience could help them in future projects that are more technical in nature.	art and science and understand better how the two are related.
Allotted Time	20 min.	
Summative Assessment	Students will wear final project to class, submit written notes on dye samples, physical samples labeled, and bibliography of sources used in research.	

Rubric

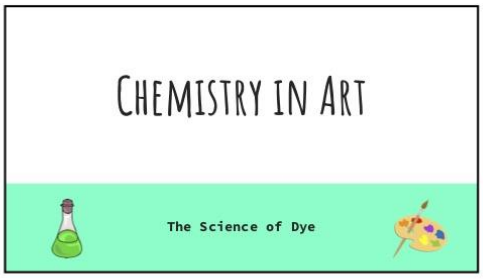
Learning Objective	**A**	**B**	**C**	**D**	**F**	**Points**
Students will understand the basic principles of dyes and dyeing.	Student is able to clearly explain their choices of dye, discuss in detail how they made and used the dyes, and describe their chosen shibori techniques.	Student can explain some of their reasoning for dye choices, the dye making process and shibori techniques.	Student can name the dyes and shibori techniques they used, and give a couple details on the process, but can't justify their choices.	Student can name the dyes and shibori techniques they used, but can't explain any part of the process further.	Student can't name or explain the dyes or shibori techniques used.	/50
Students will compare and contrast various sources on dyeing to find procedures and strategies for dyeing with natural materials.	Student has found at least 5 sources on dyeing and explained how they utilized these sources in a written bibliography.	Student has found 3-4 sources on dyeing and explained how they utilized these sources in a bibliography.	Student has found 1-2 sources and has explained how they utilized these sources in a bibliography.	Student has found 1-2 sources and has not explained them or written very little about them.	Student has found 0-1 sources and has not explained how they utilized these sources.	/20
Students will analyze the results of dye tests and make changes in process based on results.	Student has recorded and reflected on all dye tests performed in an organized manner in their sketchbook.	Student has recorded and reflected on most dye tests performed in their sketchbook.	Student has recorded most dye tests, but not reflected on many in their sketchbook.	Student has recorded some dye tests but has not reflected at all in their sketchbook.	Student has not recorded any dye tests in their sketchbook.	/30

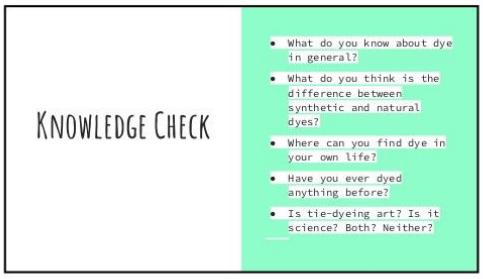
Students will test and experiment with natural dyes and the dyeing process.	Student has submitted at least 8 dye samples labeled with material, time dyed, and if mordant was used.	Student has submitted 5-7 dye samples labeled with material, time, and if mordant was used.	Student has submitted 2-4 dye samples labeled with material, time, and if mordant was used.	Student has submitted 2-4 dye samples but they are either unlabeled or labeled incorrectly.	Student has submitted 0-1 dye samples labeled or unlabeled.	/30
Students will learn to classify various natural dye materials according to their different characteristics.	Student made significant contributions to the class dye chart, (added test samples, helped develop the organizational system, collected classmates' samples, etc.) throughout the entire project.	Student contributed consistently to the class dye chart through the duration of the project, but mostly played a supporting role in its creation.	Student contributed to the class dye chart when asked, or for some parts of the project.	Student turned in dye samples for the class dye chart but otherwise did no work to help in making it.	Student did not contribute to the class dye chart at all.	/20
Students will understand the connections between science and art.	Student has demonstrated a thorough understanding of how science and art connect in relation to dyeing as well as in other art forms as demonstrated by participation in class discussions and a well-thought out of a written reflection.	Student has demonstrated an adequate understanding of how science and art connect in relation to dyeing, and some awareness of the connection in other art forms through participation in class discussions and a detailed written reflection	Student has demonstrated and adequate understanding of how science and art connect in relation to dyeing, but not in other art forms demonstrated through some participation in class discussions and a clear but brief written reflection.	Student has demonstrated some understanding of how science and art connect in relation to dyeing, but shows little participation in class discussions and provides a brief written reflection with perfunctory responses.	Student has demonstrated no understanding of how science and art connect in relation to dyeing, has not participated in class discussions, and has turned in an incredibly short, incomplete, or no written reflection at all.	/50
					Total:	**/200**

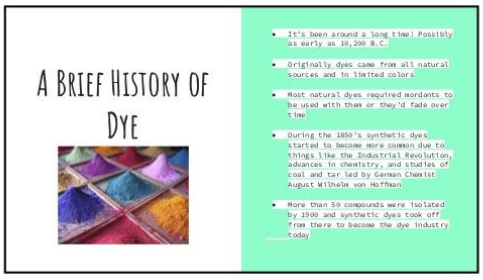
Teacher Comments:

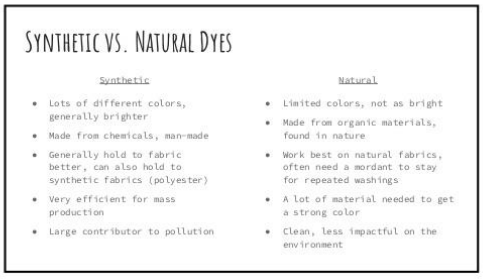
Lesson Resources

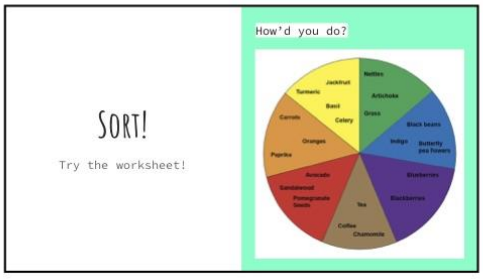
PowerPoint Presentation











Ways to Dye

Dip-dye

Batik (with or without wax)

Dye Painting

Low-water immersion

Shibori

A Japanese manual resist dyeing technique.

- Rubberbands

- Fold-resist

- Pole-wrapping

- Stitch-resist

The Project

Use **Natural Dyes** and **Shibori Techniques** to dye an item of clothing of your choice.

The Demo

Making dye from...

Blueberries!

How to Sew

For Next class

Bring in a rough sketch for your final project, and 3-4 COMPLETED Shibori samples, at least 2 of them MUST use sewing/stitch resist

Day 2: The one with the Chemistry

Day 1 Recap

- Natural vs. Synthetic Dyes
- Different dyeing techniques
  - Shibori!
- Demo: how to make dye using blueberries
- Video: how to sew
- Classifying dye materials by color

Classification

What are some ways we classify types of natural dye?

- By color (like we just did)
- By type of materials (animal, vegetable, mineral)
- By chemical structure!

Let's Review

Chemistry!

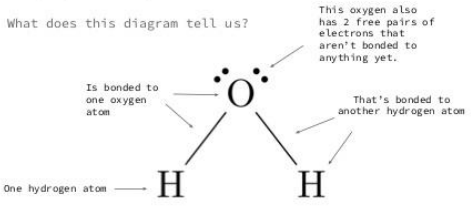
- Everything is made of **molecules**
- Molecules are made of **atoms** connected by **chemical bonds**
- Bonds are formed when atoms **share** or **exchange electrons**
- Atoms of certain **elements** bond readily with atoms of other elements to form molecules
- A **molecule** you likely know is **H2O** or **water**

Some Chemistry Basics

- Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorous, and Sulfur are considered organic elements and are important in natural dyes
  - We can remember these with the word "CHNOPS" which is a combination of all the elements' symbols
  - What are some other elements?
- Other common molecules are: CO_2, NaCl, CH_4, $NaHCO_3$, and CH_3COOH
  - Carbon dioxide, sodium chloride or salt, methane, sodium bicarbonate or baking soda and acetic acid or vinegar
- Bonds between atoms can form and break in chemical reactions
  - Cooking is a chemical reaction, can you think of some others?

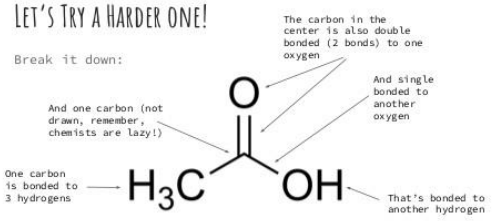
Remember: Chemists Are Lazy

What does this diagram tell us?

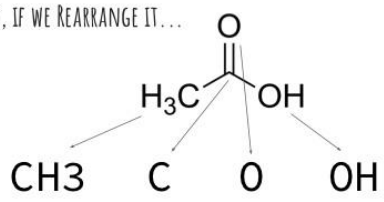


Let's Try a Harder one!

Break it down:

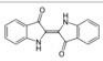


So, if we Rearrange it...



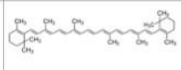
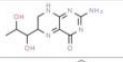
What molecule is it? ... Acetic Acid! or ... Vinegar!

Dyes Can be Classified by Chemical Structure

Chemical Name	Structure	Description
Indigoid		Dark blue, found in the indigo plant, color of denim
Pyridine Based		Few in number, produce a bright yellow

When looking at these diagrams, each corner where two lines meet represents one carbon element, and the double lines represent double bonds.

Chemical Structures Cont.

Chemical Name	Structure	Description
Carotenoid		Mainly found in plants, produce yellows and oranges characteristic of pumpkins, squash, and carrots.
Quinonoid		Very common and diverse, produce colors ranging from yellow to red
Flavonoid		Largest group of plant dyes, produce yellows, reds, and even blues

Chemical Structures Cont.

Chemical Name	Structure	Description
Dihydropyran		Found only in brazilwood and logwood
Betalains		Nitrogen-based water-soluble dyes, produce yellows and violets
Tannins		Found in most vegetables and act as a natural mordant

Today

- Start testing your shibori samples with the pre-made dyes
- Start researching natural dyes

I will be coming around to talk to you individually about your final project!

For Next Class

Start writing things down! Dyes you tested, shibori techniques you used, sources you found, etc.

Day 3: The Scientific Method

As you're coming into class, take out any shibori samples you still have soaking.

Day 2 Recap

- Went over some of the basics of chemistry
- Looked at the chemical structures used to classify dye
- Started testing some dyes and shibori techniques
- Started researching and recording data on dyes

Take 5 minutes...

Write down in your sketchbook how your tests from last class turned out

What's the project again?

Use **Natural Dyes** and **Shibori Techniques** to dye an item of clothing of your choice.

But there's a twist...

What are some similarities and differences?

Data Matters

If we want to repeat our results, we have to know what we did.

During the project you will:

- Individually keep track of all tests you do
- Find at least 5 sources about dyeing to figure out what materials you want to test and keep track of them in a written bibliography
- As a class make a chart to compile everyone's test samples in a clear organizational system

Keeping track of tests

To keep in your sketchbooks:

Test #	Dye Material	Time Dyed For	Mordant used?	Shibori Technique (optional)	Additional Notes
1	Blueberries	18 hours	Yes	Fold resist	The cardboard got really wet and didn't resist the dye completely since it soaked so long.
2					
3					

For the Remainder of Class

1. Start planning a chart
2. Think of a list of materials you want to make dye out of
3. Start stitching more shibori samples
4. Finish reflection on dye tests from last class

Homework: Make up a table in your sketchbook to record tests

Day 4: Experimentation

Day 3 Recap

- The scientific method
- Along with the project you're making:
  - A dye chart to organize our results as a class
  - A table to record all your individual test results
  - A bibliography of sources on dyeing that you're referencing in your project
- Decided what materials to test before doing the final project

Work Day!

Options for the day:

- Make dyes and test more samples
- Work on dye chart
- Research natural dyes
- Start stitching shibori for your final project

Reminders:

- Record all tests you do in your sketchbook
- Write down any sources you find
- Next class will be another work day, but you should have your final project ready BEFORE class so you can dye it.

Day 5: Work Day

Day 4 Recap

- Pull out any samples still soaking
- Write down any notes on your tests from last class

Day 5 List

Next class: Critique!

1. Get your final project dyeing!
2. Finish dye chart
3. Remember to write everything down
4. Make any last samples

Day 6: Critique!

Discussion Topics

- What materials and techniques did you use?
- What new technique or aspect of dyeing were you exploring or experimenting with?
- What's one thing you're proud of, and one thing you wish you could change?

Final Reflection

- What was successful about your project?
- What could you have done differently?
- Which parts of this project were challenging?
- Do you think this project was more about art or science?
- Can you think of any other ways that art and science might work together?

Natural Dye Materials Sorting Game

Sort these natural materials into the boxes based on what color dye you think they should produce. Consider the color of the material itself, as well as the various chemicals we talked about. Some of the materials will be harder to guess than others so do your best!

Materials

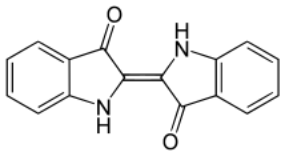
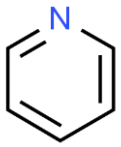
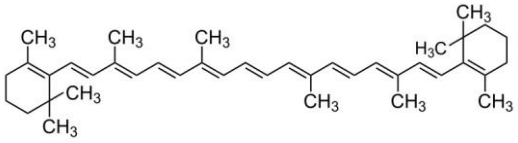
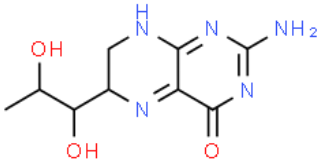
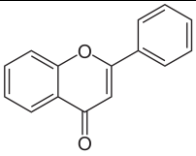
• Sandalwood • Jackfruit • Black beans • Pomegranate Seeds • Nettles • Indigo • Tea	• Avocado pits • Blackberries • Paprika • Turmeric • Oranges • Artichokes • Chamomile	• Blueberries • Coffee • Carrots • Celery • Grass • Basil • Butterfly pea flower

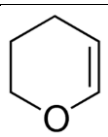
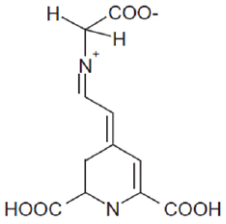
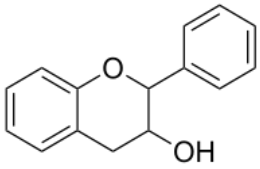
RED/PINK	ORANGE	YELLOW
GREEN	BLUE	PURPLE
	BROWN	

Dye Color Charts

During my preliminary research, I found many sources that focused on the classification of natural dyes and the different ways materials have been classified in the past, and decided to incorporate this into my project by creating my own organizational charts based on my research and test results. Dye classification charts are usually organized either by the color dye the material produces, or by the chemical compound that is present in the material that creates the dye.

Based on literature and research that already exists on the subject the chemical classification of dyes is as follows:

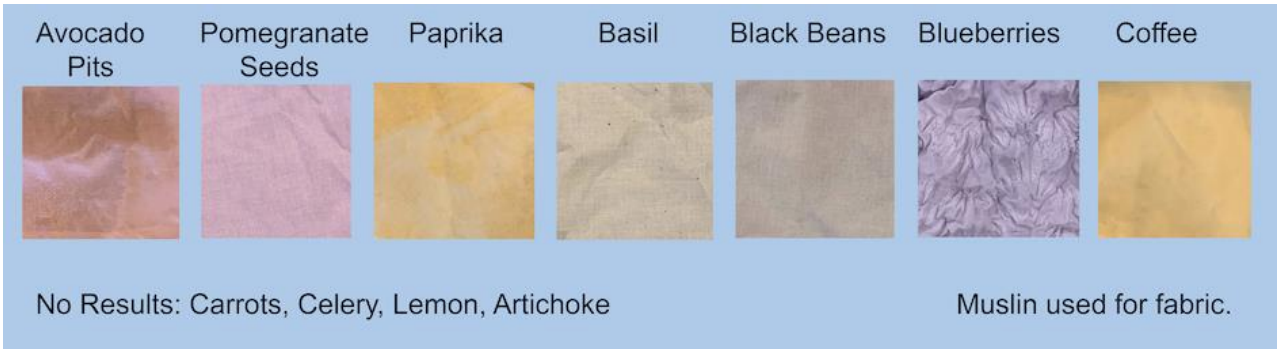
Chemical	Structure	Color
Indigoid		Dark blue, found in the indigo plant, color of denim
Pyridine Based		Few in number, produce a bright yellow
Carotenoids		Mainly found in plants, produce yellows and oranges characteristic of pumpkins, squash, and carrots.
Quinonoids		Very common and diverse, produce colors ranging from yellow to red
Flavonoids		Largest group of plant dyes, produce yellows, reds, and even blues

Dihydropyran		Found only in brazilwood and logwood
Betalains		Nitrogen-based water-soluble dyes, produce yellows and violets
Tannins		Found in most vegetables and act as a natural mordant

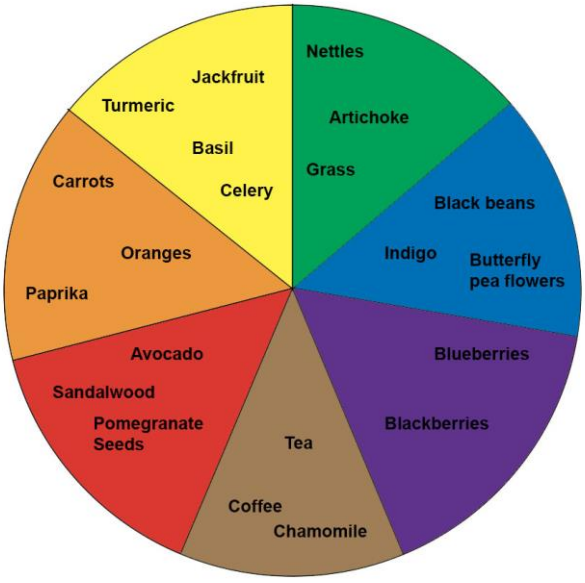
Because my project was focused more on the application of natural dyeing in artistic endeavors, I decided to use color as my primary organizing factor. In the future, a study of the chemical makeup of these materials may be an interesting topic to explore, to determine if the chemical structures and resulting colors match existing literature on the subject, but that kind of chemical analysis wasn't realistic within the limits of this project. The main takeaway that I want students to get from this chart is the understanding that all of these chemicals are entirely organic compounds, meaning they're made up entirely of carbon, hydrogen, oxygen, and nitrogen, unlike synthetic dyes, which as the name implies, contain synthetic compounds that can be harmful to the environment.

I also believe it important for students to realize that even if the chemistry behind this art form isn't directly visible, it plays a large role in the visible results, since it is the chemical structures that are present in the natural materials that create the color dye we see. In this as in many art forms, chemistry is intrinsically linked with the processes and materials being used, yet

it often goes unnoticed due to a lack of cross-over between artists and scientists, and bringing these connections to light was the inspiration behind this project.



This chart shows close-up images of the plants I personally tested and obtained results from. This would be used in the classroom as a reference for students to see generally what colors they are likely to get from these materials. From there, they can decide what materials they want to try for their own projects, as outlined in the lesson plans. One goal of the project for the students will be to develop their own charts that will ideally be more comprehensive than what I was able to do on my own.



This second chart was also made for students to reference, but as a more general idea of what color dye plants should produce according to various sources. It is also the answer key for the sorting game worksheet students receive on the first day of the project. The goal was to include mainly materials that could be easily found in the Midwestern region of the United States, but I was unable to test all of them, and some of the materials included on the chart I did test but didn't get any results from.

Chemistry Application: Testing Various Dye Materials

Background

Chemistry and art have always gone hand in hand, and almost every artistic medium relies on chemistry in some way, whether or not artists are aware of it. In some mediums, the presence of chemistry is obvious, such as in film photography and certain printmaking forms such as etching. However, chemistry is also present in many other mediums, such as ceramic glazes, the production of different paints, the function of colorants in glass blowing, and in many other ways. One other use of chemistry that I am interested in exploring is the use of natural materials in the dyeing of textiles. This has been done for almost as long as humans have existed, and while we use largely synthetic dyes now, for much of history dyes were made primarily from natural resources such as plants, bacteria, and even certain animals and bugs. One of the most common and well-known of these natural materials is the Indigo plant, used primarily in India for dyeing the skin as well such as in henna tattoos. The indigo plant produces a blue colored dye, but dyes of every color of the rainbow have been made in various ways from various materials, and each of these dyes has a specific chemical makeup that determines its color.

While there is a fair amount of research done on classification of natural dyes, including a comprehensive understanding of the chemical structures present in natural dyes, most of the practical application of this information can be found on DIY websites and in craft videos and tutorials; very little empirical data and results have been collected on the vast number of materials that can be used as dye. Therefore, the goal of this research is to begin collecting this data through a series of tests and documentation of results that can be used as reference for future experimentation.

Laboratory Objective

Create teacher samples, visuals to be used in the teaching of the lesson, and tests of a variety of natural dyes to be used in a future classroom setting, as well as in my own artistic practice.

Materials

- 3-quart pot
- 5-quart pot
- Wooden spoon
- Squares of muslin (as many as needed)
- Mordant (soda ash)
- Various natural materials to use as dye
    - Avocado pits
    - Coffee
    - Blueberries
    - Artichoke
    - Carrot
    - Paprika
    - Celery
    - Basil
    - Black beans
    - Pomegranate seeds
    - Lemons
- Shibori test samples
- Towels
- Gloves

General Procedure

1. Select natural material to be used, and prepare it for boiling (this varies depending on the material, often it involves cutting it up to expose more surface area).

    Notable Exceptions:

    i. Avocado pits must be removed and cleaned

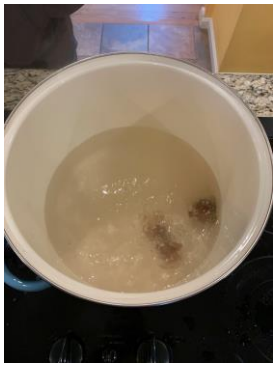
    ii. Smaller items such as berries or spices can be added directly to water

    iii. Coffee can be made normally (ex. in a coffee maker)

2. Fill the 3-quart pot about one-fourth of the way with water, or enough to completely cover the dye materials.
3. Heat water until boiling, then let the materials simmer for about an hour or until the water appears colored.
4. Strain the materials out of the pot (the liquid that remains is the dye), let the liquid cool.
5. As dye cools, prepare mordant solution
    a. Fill the 5-quart pot with a gallon of water, add ½-1 cup of mordant (soda ash) to the water, and heat gently, stirring occasionally to dissolve the particles.
    b. Let fabric soak in solution for about 20 minutes, then, while wearing gloves, remove the fabric and wring it out, DO NOT rinse.
6. Place mordant-soaked fabric in dye for about an hour, or until desired color is reached. Let dry.

This procedure is explained in detail in a video tutorial I made to go along with this project: https://www.youtube.com/watch?v=r1Ld31SRyH8

Data and Observations

	Mordant Bath, soda ash used as mordant		Test Squares, two different types of muslin used, half of total test squares soaked in mordant, half left without, “M” mark indicates use of mordant.
	Avocado pits boiling in progress, image 1 of 4. Avocado pits are meant to produce a light pink dye.		Avocado pits boiling in progress, image 2 of 4. The water is beginning to change colors as the tannins are released from the pits.
	Avocado pits boiling in progress, image 3 of 4. Water continues to get darker as the pits continue heating.		Avocado pits boiling in progress, image 4 of 4. The pits have opened/split, with layers of skin coming off, the water is darker still.
	Fabric test squares added to the dye, four total, two of each type of fabric, one of each with mordant and one of each without.		Results of avocado dye, samples were left in dye for thirty minutes. No real difference noted between different fabric types or use of mordant. Light pink color resulted as predicted

	Coffee as dye, with fabric samples in dye. Light brown color is expected.		Dye results after one hour, with and without mordant. Light brown color resulted as predicted.
	First shibori test, strings pulled tight, no mordant used.		Results of first shibori test, placed in avocado dye overnight, strings removed.
	Second shibori test, before pulling the string tight.		Result of second shibori test, placed in avocado dye overnight, mordant used. No apparent difference between sample with mordant and sample without.
	Blueberries boiling in progress, image 1 of 3. Purple dye expected. Berries initially float, covering the surface of the water.		Blueberries boiling in progress, image 2 of 3. Berries begin to change color and expand as water is absorbed, the water also begins to turn a deep red.

	Blueberries boiling in progress, image 3 of 3. Water has turned an even darker red, and the berries are beginning to dissolve, the skins sinking to the bottom.		Blueberry dye with fabric test samples added. Dye appears more red than expected.
	Shibori test 3, before tightening string.		Initial test samples from blueberry dye and shibori test 3, all dyed one hour.
	Shibori test 3 results, mordant used, green coloration in white areas may have resulted from an interaction between the dye and the mordant.		Shibori test 4, this method uses a different resist technique that doesn't require stitching. Areas of resist are created by the cardboard and rubber-bands instead.
	Additional blueberry samples and shibori test 4, dyed overnight, approximately 18 hours, resulting color much darker than previous samples.		Shibori test 4 results, dye soaked through cardboard overnight, dyeing resist areas but not as much as the exposed edges. Mordant was used, but there is no discoloration, possibly due to long dyeing time.

	Artichoke dye, meant to dye green, no results obtained, fabric that soaked overnight had no color change.		Carrot dye, meant to dye orange, no results, even with vinegar added to potentially draw out more dye, samples remained uncolored.
	Paprika dye. Orange color expected. A large amount of spice was required to produce a decent color.		Paprika dye samples, dyed overnight, approximately 18 hourse.
	Celery dye, meant to turn yellow, no results. Dyeing overnight produced no color change.		Basil dye, boiling in progress, image 1 of 3. Purple expected.
	Basil dye, boiling in progress, image 2 of 3, water beginning to turn a yellowish-brown color.		Basil dye image 3 of 3, after straining and cooling. Dye is a light yellow-brown color.

	Basil test sample results, online sources said dye would be grayish purple, but specified opal basil being used instead of normal basil which was used here.		Basil sample (bottom) compared to plain fabric. Color change is minimal after soaking overnight, approximately 14 hours.
	Black bean dye image 1 of 2, organic uncooked beans were used, and just soaked instead of boiled, blue expected.		Black bean dye image 2 of 2, water turned deep blue-gray.
	Black bean test sample results, soaked overnight, about 14 hours. Samples came out more gray/purple than blue.		Pomegranate dye image 1 of 2. Online sources recommend using the rinds, but I was only able to find seeds at the store, not whole fruit. The seeds were allowed to soak overnight before boiling the next day.
	Pomegranate dye image 2 of 2. After soaking the water was noticeably redder, and grew darker as the seeds were boiled. Reddish-pink color was expected.		Pomegranate test sample results, soaked overnight, about 14 hours.

Dye Results: Shibori Techniques Tested

1. Object Resist



2. Folding and Stitching



3. Straight Stitching (lines and shapes)